OPERATING INSTRUCTIONS

TYPE 1232-A

TUNED AMPLIFIER AND NULL DETECTOR

GENERAL RADIO COMPANY

B

OPERATING INSTRUCTIONS

TYPE 1232-A

TUNED AMPLIFIER AND NULL DETECTOR

Form 1232-0100-B
April, 1962

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West Concord, Massachusetts, USA

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

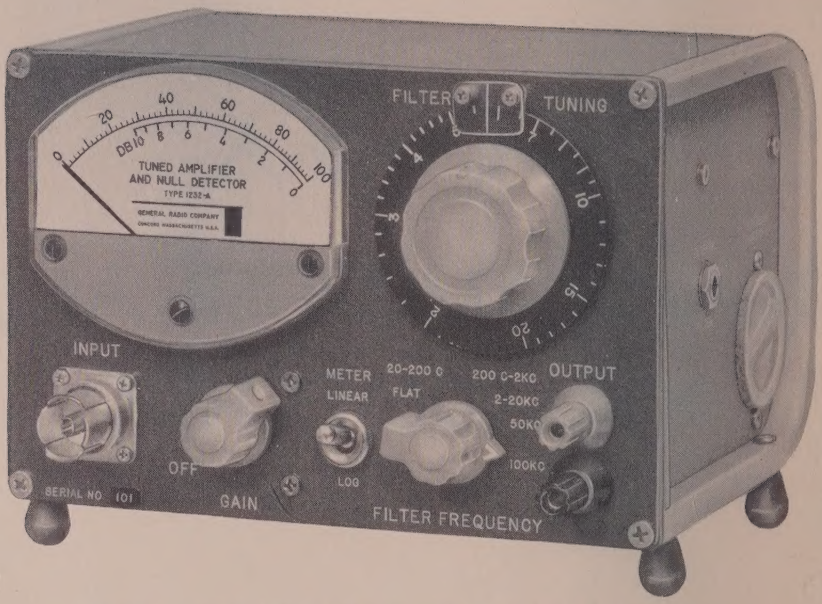


Figure 1. Type 1232-A Tuned Amplifier and Null Detector.

SPECIFICATIONS

Frequency Response:

Tunable Filters: 20 cps to 20 kc in 3 ranges; 6% bandwidth; 2nd harmonic at least 34 db down from peak, 3rd at least 40 db down; rejection filter on two highest ranges reduces 60-cycle level to at least 60 db below peak. Frequency dial accuracy is ±3%.

50-kc and 100-kc Filters: 2nd harmonic at least 60 db down.

Flat Response: ±3 db, 20 cps to 100 kc.

Sensitivity: One microvolt, full-scale, or better, over most of the frequency range.

Noise Level at Output Terminals: Less than 50 mv at minimum gain. See Figure 6.

Input Impedance: Approximately 50 kilohms to one megohm, depending on gain-control setting.

Max Input Voltage: 200 volts ac or 400 volts dc.

Gain: 120 db on the tunable ranges; 100 db, flat range; 106 db at 50 kc; 100 db at 100 kc position.

Output: 1 volt into 10,000 ohms. Internal impedance is 3000 ohms.

Meter Linearity: Db differences on scale are accurate to ±5% for inputs of less than 0.3 volt.

External Filter: Source impedance, 700 ohms.

Compression: Reduces full-scale sensitivity by 40 db. Does not affect bottom 20% of scale.

Distortion: (In flat position) less than 5%, practically all attributable to the meter rectifiers.

Power Supply: 12 volts dc, from 9 mercury (M72) cells in series. Estimated battery life is 1500 hours. Cost is about 0.4 cent per hour.

Transistor Complement: Five 2N169A, two 2N1395, one 2N929.

Accessories Supplied: Type 874-C58 Cable Connector.

Dimensions: Width 8, height 6, depth 7-1/2 inches (205 by 150 by 190 mm) over-all.

Net Weight: 5-3/4 pounds (2.6 kg).

U.S. Patent No. 2,548,457 and D 187,740

TYPE 1232-A
TUNED AMPLIFIER
AND NULL DETECTOR

Section 1
INTRODUCTION

1.1 PURPOSE.

The Type 1232-A Tuned Amplifier and Null Detector (Figure 1) is a sensitive, low-noise amplifier continuously tunable from 20 cps to 20 kc, with additional fixed-tuned frequencies of 50 kc and 100 kc. Intended primarily as a bridge detector, the Type 1232-A can also be used as a detector of high-frequency modulated signals (with a crystal demodulator), a wave analyzer at audio frequencies, and a preamplifier for transducers.

1.2 DESCRIPTION.

The Type 1232-A consists of a low-noise preamplifier, a frequency-selective stage (feedback amplifier and null network), an amplifier-compressor stage, and a meter-rectifier circuit (see block diagram, Figure 2). The total gain of the amplifier is about 120 db. Full-scale meter sensitivity is 1 microvolt or better over most of the frequency range.

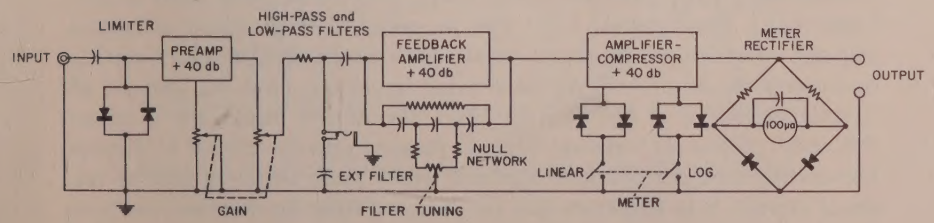


Figure 2. Block schematic of the null detector.

With the Type 1632-A Inductance Bridge, this null detector permits inductance balances to a resolution of 1 part in 10^6. Comparable precision for capacitance balance can be obtained with the Type 716-C Capacitance Bridge.

The amplifier is powered by 12 volts dc, supplied by nine mercury batteries in series. The output is 1 volt into 10,000 ohms.

1.3 CONTROLS AND CONNECTORS.

The following table lists controls and connectors on the Type 1232-A Tuned Amplifier and Null Detector:

Name	Type	Function
FILTER TUNING	Continuous rotary control	Tunes filter within selected tuning range.
FILTER FREQUENCY	6-position rotary switch	Selects desired frequency characteristic: tuning-frequency range of 20-200 cps, 200 cps - 2 kc, or 2-20 kc; flat, 50-kc or 100-kc response.
GAIN	Rotary control	Turns instrument on or off and controls gain.
METER	Toggle switch	Selects linear or logarithmic response.
INPUT	Type 874 Coaxial Connector	Input terminals.
OUTPUT	Pair of Type 938 Binding Posts	Output terminals.
EXT FILTER	Phone jack	Connection for external filter.

1.4 USE OF EXTERNAL FILTERS.

External filters can be connected at the EXT FILTER jack. When a telephone plug is inserted in this jack, the built-in shunt filter is disconnected. The external filter may be either a series-tuned circuit to trap out an undesired frequency or an antiresonant parallel-tuned circuit to improve the selectivity at the desired frequency. For the purpose of calculating the Q of the external filter, the source impedance is about 700 ohms. Since the external filter is plugged into the circuit at a point beyond the 60-cps rejection filter and where there is 80-db gain to the meter circuit, it is important that the external filter be shielded and preferably that it use a toroidal inductor for minimum sensitivity to hum pickup.

Section 2
PRINCIPLES OF OPERATION

2.1 PREAMPLIFIER.

The preamplifier stage of the Type 1232-A Tuned Amplifier and Null Detector is designed to minimize noise from both low-impedance sources, such as inductance bridges at low frequencies, and high-impedance sources, such as capacitance bridges at low frequencies.[1] A transistor with a noise figure of 3 to 5 db at an optimum source impedance of 50 kilohms is used. By use of negative feedback, the input impedance of the preamplifier is also made 50 kilohms, and the noise level indicated on the output meter is relatively constant and independent of source impedance.

The input transistor is protected from possible damage due to large overloads by a limiter consisting of a series capacitor and two shunt silicon rectifier diodes. This circuit effectively prevents signals greater than 1 volt, peak-to-peak, from reaching the input transistor and does not contribute noise or distortion to low-level signals.

Maximum gain of the preamplifier is about 40 db, which is adequate to swamp the noise of succeeding stages. After preamplification, the signal passes through a set of series and shunt filters, which are designed to reject frequencies above and below the selected tuning range. Typical filter characteristics are shown in Figure 3. On all switch po-

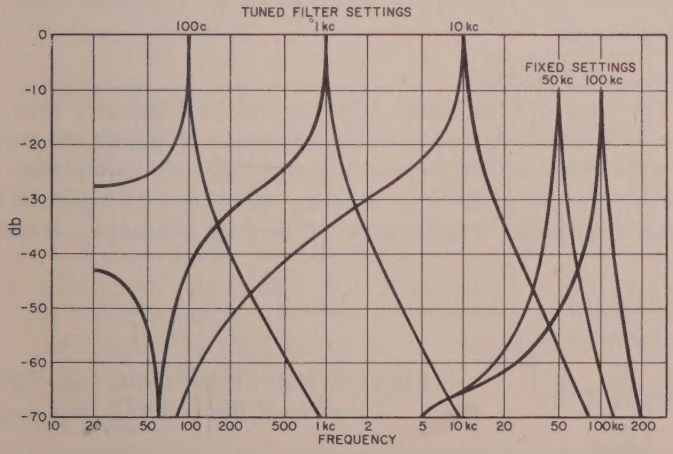


Figure 3. Typical filter characteristics of the Type 1232-A.

[1] A. E. Sanderson and R. G. Fulks, "A Simplified Noise Theory, and its Application to the Design of Low-Noise Amplifier," IRE Transaction on Audio, July-August, 1961.

sitions except FLAT and 20 - 200 C, another rejection filter reduces the response at 60 cps to greater than 60 db below peak response.

2.2 FREQUENCY-SELECTIVE AMPLIFIER.

This amplifier consists of three stages with negative feedback through a null network, which has its null at the desired operating frequency. Since there is negative feedback at all frequencies but the desired one, the over-all response peaks at this frequency and is roughly equivalent to that of a tuned circuit with a Q of about 20 (5% bandwidth). The unique feature of this null network is its one-potentiometer tuning. Many null networks require three variable elements, either ganged capacitors or ganged potentiometers. This leads to many problems in alignment and tracking the three elements to maintain a good null. The Hall null network[2] has a perfect null in theory for any position of the tuning potentiometer, and it is possible to cover a 10:1 tuning range with a 40-db exponential potentiometer. Tuning capacitors are switched to change ranges, maintaining the impedance level of the null network approximately constant for the three tuning ranges.

Since the 50-kc and 100-kc null networks need not be tunable, conventional twin-T null networks are used.

On the FLAT position of the range switch, all filters are switched out and the frequency response is flat to within ±3 db from 20 cps to 100 kc. The overall gain of the amplifier is reduced by 26 db to keep the noise level on the output meter equal to about 10 percent of full scale at maximum gain.

2.3 NULL NETWORK.

The Type 1232-A Tuned Amplifier and Null Detector uses an RC null network with only one variable component to adjust the frequency of the null. This avoids the use of ganged variable components, which must track closely to maintain stability when used in highly selective feedback amplifiers. The network (Figure 4), consisting of three-ter-

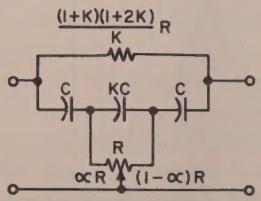


Figure 4. Null Circuit of the Type 1232-A Tuned Amplifier and Null Detector.

[2] Henry P. Hall, IRE Transactions on Circuit Theory, September 1955, Vol CT-2, No. 3, p 283; *General Radio Experimenter*, Vol 35, No. 7, July, 1961, p 8.

minal RC circuits, gives a complete null without being balanced against a voltage divider, and permits frequency adjustment with a single potentiometer. The tuning law for this circuit is

$$\omega_o = \frac{1}{RC\sqrt{a(1-a)}}$$

In order to span a 10-to-1 logarithmic frequency range, the potentiometer must have an exponential characteristic of over 100 to 1.

The selectivity of the transfer admittance, $\frac{I_o}{E_{in}}$ (or Y_{21}), is quite constant as the null frequency is changed. In order to use this characteristic, the network must be driven by and loaded by low impedances. Therefore, it is used in a feedback circuit with an amplifier having low input and output impedances and a transfer resistance $\frac{E_o}{I_{in}}$ (or a real Z_{12}) that is chosen to give the desired selectivity. This combination provides a second-harmonic rejection of 34 db over each 10-to-1 frequency range.

2.4 AMPLIFIER-COMPRESSOR.

With the METER switch set to the LINEAR position, the amplifier-compressor functions as a linear amplifier, driving the meter rectifier circuit and supplying the output terminals with about 1.4 volts for full-scale deflection of the meter. The dc supplied to the last transistor is sufficient to drive the output meter to full scale, but very little more, so that it is impossible to damage the meter by overdriving the amplifier.

For null detector use, the METER switch is thrown to LOG, effectively compressing the upper part of the meter scale. Two pairs of silicon diodes are switched in shunt with the collector resistors of two transistors to provide a nonlinear collector impedance. Owing to the voltage offset of the silicon diodes, the bottom 20 percent of the meter scale is virtually unaffected. A signal level corresponding to 100 percent deflection for linear response will drop to 50 percent for logarithmic response. An increase of 20 db increases the reading to 80 percent, and another 20 db raises the reading to 100 percent.

2.5 METER CIRCUIT.

The meter circuit uses a full-wave rectifier in order to double the ripple frequency that passes through the meter and thus to prevent the needle from vibrating visibly at 20 cps. Resistors are used in place of two of the rectifiers in the conventional full-wave bridge in order to linearize the relation between meter indication and signal level, and to

minimize distortion. No dc amplification was incorporated into the meter circuit, so that there is no need for a dc zero adjustment on the front panel and no possibility of dc zero instability. High-impedance, crystal-type earphones can be connected to the output terminals.

Section 3
OPERATING PROCEDURE

3.1 USE AS AN AMPLIFIER OR PREAMPLIFIER.

To use the Type 1232-A Tuned Amplifier and Null Detector as an amplifier:

a. Connect the input signal to the INPUT connector. Adaptors for connectors other than Type 874 are available from General Radio (see table at rear of this manual).

NOTE

For connection to binding posts, use a Type 874-R34 Patch Cord. (Hum pickup is too great with a Type 874-Q2 Adaptor.)

b. Set the METER switch to LINEAR.

c. Set the FILTER FREQUENCY switch for the desired characteristic: FLAT, 20-200 C, 200 C - 2 KC, 2-20 KC, 50 KC, or 100 KC.

d. With the GAIN control, turn the instrument on and adjust the gain to the desired level. The total range of the GAIN control is 120 db, and attenuation in db is roughly proportional to the rotation angle of the control knob.

e. The OUTPUT terminals may be connected to an oscilloscope or headphones. The red binding post is high, the black binding post is ground.

The high sensitivity of this instrument permits its use as a preamplifier for transducer outputs or oscilloscope input.

3.2 USE AS A NULL DETECTOR FOR BRIDGE BALANCING.

To use this instrument as a detector for bridge measurements:

a. Connect the INPUT terminals of the Type 1232-A to the DETECTOR terminals of the bridge.

b. Set the METER switch to LOG.

c. Set the FILTER FREQUENCY and FILTER TUNING controls to the desired frequency.

d. With generator and unknown connected to the bridge, set the GAIN control of the Type 1232-A for approximately half-scale deflection of the output meter, and tune the FILTER TUNING control for maximum output.

The bridge balance can now be made in the conventional manner, readjustment of the GAIN control as balance is approached.

3.3 USE AS A DETECTOR-DEMODULATOR.

For the detection of modulated high-frequency signals, the Type 1232-A Amplifier and Null Detector can be used with the Type 874-VQ Voltmeter Detector. Sensitivity is approximately 200 μv full-scale up to about 2000 Mc. The crystal output of the Type 874-VQ Voltmeter Detector should be connected through a Type 874-R22 Patch Cord to the INPUT connector of the Type 1232-A. The FILTER FREQUENCY and FILTER TUNING controls should be set to the frequency of the modulation on the high-frequency signal.

3.4 USE IN AUDIO SPECTRUM ANALYSIS.

The tuned amplifier can be used as an audio-frequency wave analyzer with a sensitivity of 1 μv and a bandwidth of about 5 percent. For approximate measurements, the gain can be assumed to be constant with frequency. More accurate measurements can be obtained if the amplifier is first calibrated with a constant-amplitude, variable-frequency signal. The typical variation of peak response vs frequency is shown in Figure 5.

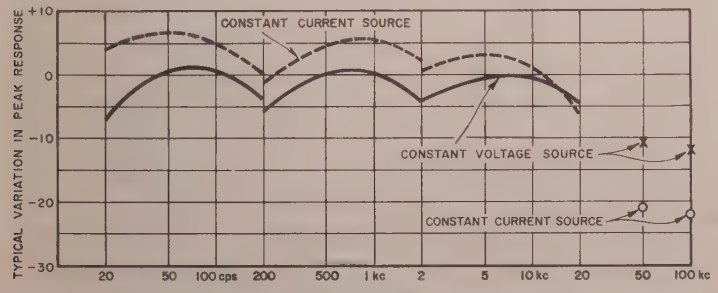


Figure 5. Typical variation in peak response with frequency for constant gain-control setting.

Section 4
SERVICE AND MAINTENANCE

4.1 GENERAL.

The two-year warranty given with every General Radio instrument attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible.

In case of difficulties that cannot be eliminated by the use of these service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office (see back cover), requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.2 REMOVAL OF COVER.

To open the instrument for access to transistors and components, loosen the two fluted captive screws at the rear of the instrument and slide the U-shaped dust cover away from the panel. All transistors and components are now accessible.

4.3 BATTERY REPLACEMENT.

The Type 1232-A Tuned Amplifier and Null Detector is powered by nine M72 mercury batteries (Mallory RM-4R or equivalent), which will last for over 1500 hours with normal use. For a simple check of the batteries, measure the dc voltage between anchor terminal 6 and ground. This should be 12 volts.

To replace the batteries, remove the cap (twist counterclockwise and pull out) on the right-hand side of the instrument under the M72 CELLS engraving. Batteries must be inserted with the positive (+) ends facing into the instrument.

4.4 INTERNAL NOISE.

At certain frequencies the sensitivity of the Type 1232-A Tuned Amplifier and Null Detector greatly exceeds the catalog specifications. With maximum gain at these frequencies, the noise generated by transistor Q100 normally causes large deflection of the output meter. For maximum useful gain, the GAIN control should be set low enough so that the noise level at the output is not greater than 10 percent of full scale.

For minimum sensitivity to hum pickup and stray fields, input connections must be shielded. Do not use an adaptor from the Type 874 INPUT connector to binding posts; use a shielded Type 874 cable.

If, with completely shielded input connections, the noise level of the Type 1232-A greatly exceeds the values given in Figure 6, the noise is probably caused by Q100. If it is necessary to replace this transistor, a replacement with a high β (beta) will usually give the lowest noise levels.

It is possible, but not likely, that Q101 will contribute significantly to the internal noise. If it is necessary to replace Q101, select a Type 2N169A transistor with a β greater than 60.

Due to the large amount of amplification that follows the GAIN control, there is always a small amount of noise present at the output terminals. At minimum gain, this should be less than 50 mv and should cause no more than 1 percent deflection of the output meter. This noise is generally caused by Q201, which may be caused by Q200, which can be interchanged with Q202, or replaced. Occasionally, the noise may be caused by Q200, which can be interchanged with Q203, Q204, or Q205 or replaced.

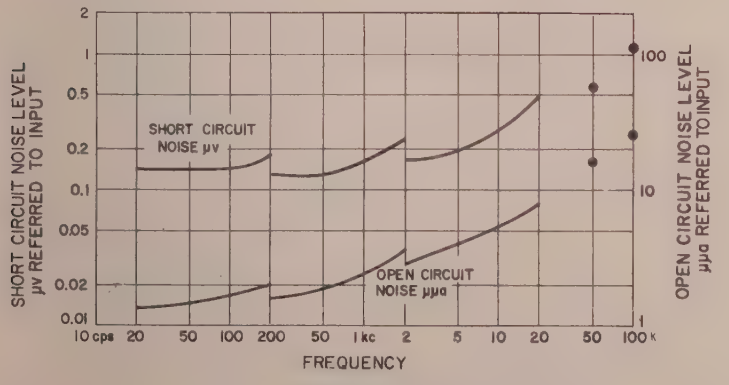


Figure 6.
Typical noise levels as a function of frequency.

4.5 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS.

The following table gives the normal voltage and resistance measurements from transistor terminals to ground. A deviation of 10 percent from any of these values is not necessarily abnormal.

TABLE OF VOLTAGES AND RESISTANCES

Transistor (Type)	Term.	Dc Volts To Ground	Ohms To Ground	Transistor (Type)	Term.	Dc Volts To Ground	Ohms To Ground
Q100	C	7.8	222 k	Q202	C	0	0
(TR-2/2N929)	E	3.6	220 k	(2N1395)	E	3.5	11 k
	B	3.7	3.3 M		B	3.3	22 k
Q101	C	11.6	2.2 k	Q203	C	1.7	100 k
(TR-1/2N169A)	E	7.7	40 k	(TR-1/2N169A)	E	0.4	4.7 k
	B	7.8	222 k		B	0.5	42 k
Q200	C	7.4	34 k	Q204	C	3.6	47 k
(TR-1/2N169A)	E	3.6	33 k	(TR-1/2N169A)	E	1.6	10 k
	B	3.7	120 k		B	1.7	100 k
Q201	C	3.3	22 k	Q205	C	7.2	4.4 k
(2N1395)	E	7.8	23 k	(TR-1/2N169A)	E	3.5	3.3 k
	B	7.4	34 k		B	3.6	47 k

1. Before making transistor voltage measurements, make sure that the battery voltage is approximately 12 volts (refer to paragraph 4.3). Turn the instrument on but leave the GAIN control counterclockwise, set the FILTER FREQUENCY switch to FLAT and the METER switch to LINEAR. Measure voltage with a vacuum-tube voltmeter.

2. Before making resistance measurements, remove all the batteries and short-circuit anchor terminal 6 to ground. Remove all transistors. Set the GAIN control to OFF, the FILTER FREQUENCY switch to FLAT, and the METER switch to LINEAR.

4.6 TRIMMER-CAPACITOR ADJUSTMENT.

Normally, the factory-set trimmer capacitor adjustment (C202) will not require attention. However, adjustment may be necessary if transistor Q201, Q203, or Q204 is replaced. If the frequency response for the FLAT characteristic is outside the specified limits, adjust the trimmer capacitor as follows:

a. With the FILTER FREQUENCY switch set at FLAT and a 1-kc signal at the INPUT connector, adjust the GAIN control for a 5-db meter indication.

b. With the GAIN and FILTER FREQUENCY controls unchanged, apply a 100-kc signal (of the same amplitude as the 1-kc signal) to the INPUT connector and adjust the trimmer capacitor, C202, for a meter indication of 5 db. Check the frequency response below 100 kc to make sure it is within the specified limits.

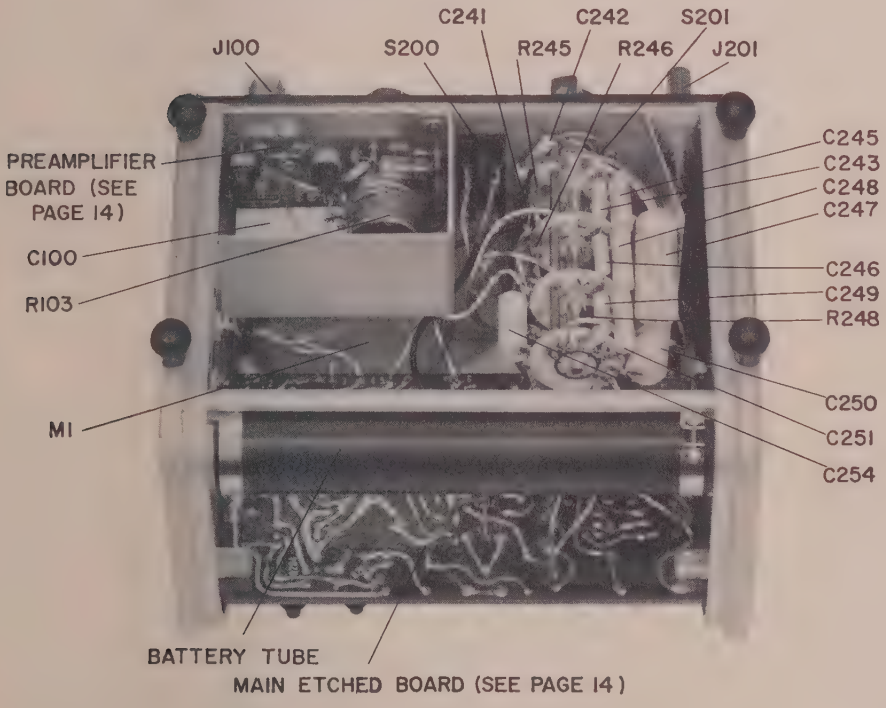


Figure 7. Bottom interior view of the Type 1232-A.

PARTS LIST

RESISTORS		(NOTE A)		PART NO. (NOTE B)
R100	3.3 M	±5%	1/2 w	REC-20BF(335B)
R101	220 k	±5%	1/2 w	REC-20BF(224B)
R102	2.2 k	±5%	1/2 w	REC-20BF(222B)
R103A	500 k	Part of 1232-40		
R103B	10 k			
R104	220 k	±5%	1/2 w	REC-20BF(224B)
R105	22 k	±5%	1/2 w	REC-20BF(223B)
R106	18 k	±5%	1/2 w	REC-20BF(183B)
R200	33 k	±5%	1/2 w	REC-20BF(333B)
R201	33 k	±5%	1/2 w	REC-20BF(333B)
R203	1 k	±5%	1/2 w	REC-20BF(102B)
R204	220 k	±5%	1/2 w	REC-20BF(224B)
R205	220 k	±5%	1/2 w	REC-20BF(224B)
R206	1 k	±5%	1/2 w	REC-20BF(102B)
R207	22 k	±5%	1/2 w	REC-20BF(223B)
R208	470	±5%	1/2 w	REC-20BF(471B)
R210	22 k	±5%	1/2 w	REC-20BF(223B)
R211	1.5 k	±5%	1/2 w	REC-20BF(152B)
R212	10 k	±5%	1/2 w	REC-20BF(103B)
R213	470	±5%	1/2 w	REC-20BF(471B)
R214	110 k	±5%	1/2 w	REC-20BF(114B)
R215	150 k	±5%	1/2 w	REC-20BF(154B)
R216	27 k	±5%	1/2 w	REC-20BF(273B)
R217	22 k	±5%	1/2 w	REC-20BF(223B)
R218	100 k	±5%	1/2 w	REC-20BF(104B)
R220	4.7 k	±5%	1/2 w	REC-20BF(472B)
R221	2.2 k	±5%	1/2 w	REC-20BF(222B)
R222	47 k	±5%	1/2 w	REC-20BF(473B)
R223	10 k	±5%	1/2 w	REC-20BF(103B)
R224	12 k	±5%	1/2 w	REC-20BF(123B)
R225	3.9 k	±5%	1/2 w	REC-20BF(392B)
R226	3.3 k	±5%	1/2 w	REC-20BF(332B)
R227	1.8 k	±5%	1/2 w	REC-20BF(182B)
R228	2.7 k	±5%	1/2 w	REC-20BF(272B)
R230	9.1 k	±5%	1/2 w	REC-20BF(912B)
R231	22 k	±5%	1/2 w	REC-20BF(223B)
R232	9.1 k	±5%	1/2 w	REC-20BF(912B)
R233	31.6 k	±1%	1/8 w	REF-60(3162A)
R234	31.6 k	±1%	1/8 w	REF-60(3162A)
R235	3.32 k	±1%	1/8 w	REF-60(3321A)
R236	3.32 k	±1%	1/8 w	REF-60(3321A)
R237	40.2 k	±1%	1/8 w	REF-60(4022A)
R238	1 k	±5%	1/2 w	REC-20BF(102B)
R239	5.11 k	±1%	1/8 w	REF-60(5111A)
R240	5.11 k	±1%	1/8 w	REF-60(5111A)
R241	1.1 k	±1%	1/8 w	REF-60(112A)
R242	4.99 k	±1%	1/8 w	REF-60(4991A)
R243	4.99 k	±1%	1/8 w	REF-60(4991A)
R244	1.05 k	±1%	1/8 w	REF-60(1051A)
R245	1.8 k	±5%	1/2 w	REC-20BF(182B)
R246	3.3 k	±5%	1/2 w	REC-20BF(332B)
R247	19.6	±1%	1/2 w	REF-70(0196A)
R248	6.65 k	±1%	1/2 w	REF-70(6651A)
R250	975-4040			

CAPACITORS		(NOTE C)		
C100	0.15 µf	±10%	600 v	COP-25(154C)
C101	1 µf	±20%	35 dcwv	COE-60(105D)
C102	3.3 µf	±20%	15 dcwv	COE-60(335D)
C103	6.8 µf	±20%	6 dcwv	COE-60(685D)
C104	4.7 µf	±20%	10 dcwv	COE-60(475D)
C200	5 µf		50 dcwv	COE-57
C201	220	±10%		COM-15B(221C)
C202	8-50	± 5%		COT-294
C204	30	±10%		COM-15B(300C)
C205	200 µf		6 dcwv	COE-44
C206	100	±10%		COM-15B(101C)
C207	60 µf		25 dcwv	COE-47
C208	60 µf		25 dcwv	COE-47
C209	0.22 µf	±10%	100 v	COP-24(224C)
C210	10 µf	±20%	20 v	COE-61(106D)
C211	680	±10%	NM	COC-21(681C)
C212	5 µf		50 dcwv	COE-57
C213	680	±10%	NM	COC-21(681C)
C214	5 µf		50 dcwv	COE-57
C215	5 µf		50 dcwv	COE-57
C216	5 µf		50 dcwv	COE-57
C217	15 µf		15 dcwv	COE-55
C218	5 µf		50 dcwv	COE-57
C219	0.464 µf	± 2%	100 v	COP-24(4643A1)
C220	0.464 µf	± 2%	100 v	COP-24(4643A1)
C221	0.464 µf	± 2%	100 v	COP-24(4643A1)
C222	464	± 1%		COM-22F(4640A)
C223	464	± 1%		COM-22F(4640A)
C224	464	± 1%		COM-22F(4640A)
C225	0.001 µf	± 1%		COM-22F(102A)
C226	0.001 µf	± 1%		COM-22F(102A)
C227	0.001 µf	± 1%		COM-22F(102A)
C230	0.01 µf	± 2%	100 v	COP-24(103A1)
C231	0.00681µf	±2%	200 v	COP-24(6811A1)
C239	6.8 µf	±20%	6 dcwv	COE-60(685D)
C240	0.015 µf	±10%	100 v	COP-24(153C)
C241	0.0022 µf	±10%	200 v	COP-24(222C)
C242	0.001 µf	±10%	200 v	COP-24(102C)
C243	0.01 µf	± 2%	100 v	COP-24(103A1)
C244	1 µf	± 2%	100 v	COP-24(105A1)
C245	0.1 µf	± 2%	100 v	COP-24(104A1)
C246	0.01 µf	± 2%	100 v	COP-24(103A1)
C247	1 µf	± 2%	100 v	COP-24(105A1)
C248	0.1 µf	± 2%	100 v	COP-24(104A1)
C249	0.01 µf	± 2%	100 v	COP-24(103A1)
C250	1 µf	± 2%	100 v	COP-24(105A1)
C251	0.1 µf	± 2%	100 v	COP-24(104A1)
C252	0.0033 µf	±10%	200 v	COP-24(332C)
C253	0.047 µf	±10%	100 v	COP-24(473C)
C254	0.22 µf	±10%	100 v	COP-24(224C)

Parts List continued on page 13

PARTS LIST (cont)

BATTERY			
BT1	12 volts 9 cells		ASA-M72
CHOKES			
L200	2200 µh ±10%		CHM-7
L201	1000 µh ±10%		CHM-6
L203	390 µh ±10%		CHM-5
DIODES			
CR100	1N1692	CR202	1N1692
CR101	1N1692	CR203	1N1692
CR200	1N1692	CR204	1N191
CR201	1N1692	CR205	1N191

METER			
M1			MEDS-122
SWITCHES			
S100	part of 1232-40		
S200			SWT-333
S201			SWRW-241
TRANSISTORS (NOTE D)			
Q100	TR-2/2N929	Q202	2N1395
Q101	TR-1/2N169A	Q203	TR-1/2N169A
Q200	TR-1/2N169A	Q204	TR-1/2N169A
Q201	2N1395	Q205	TR-1/2N169A

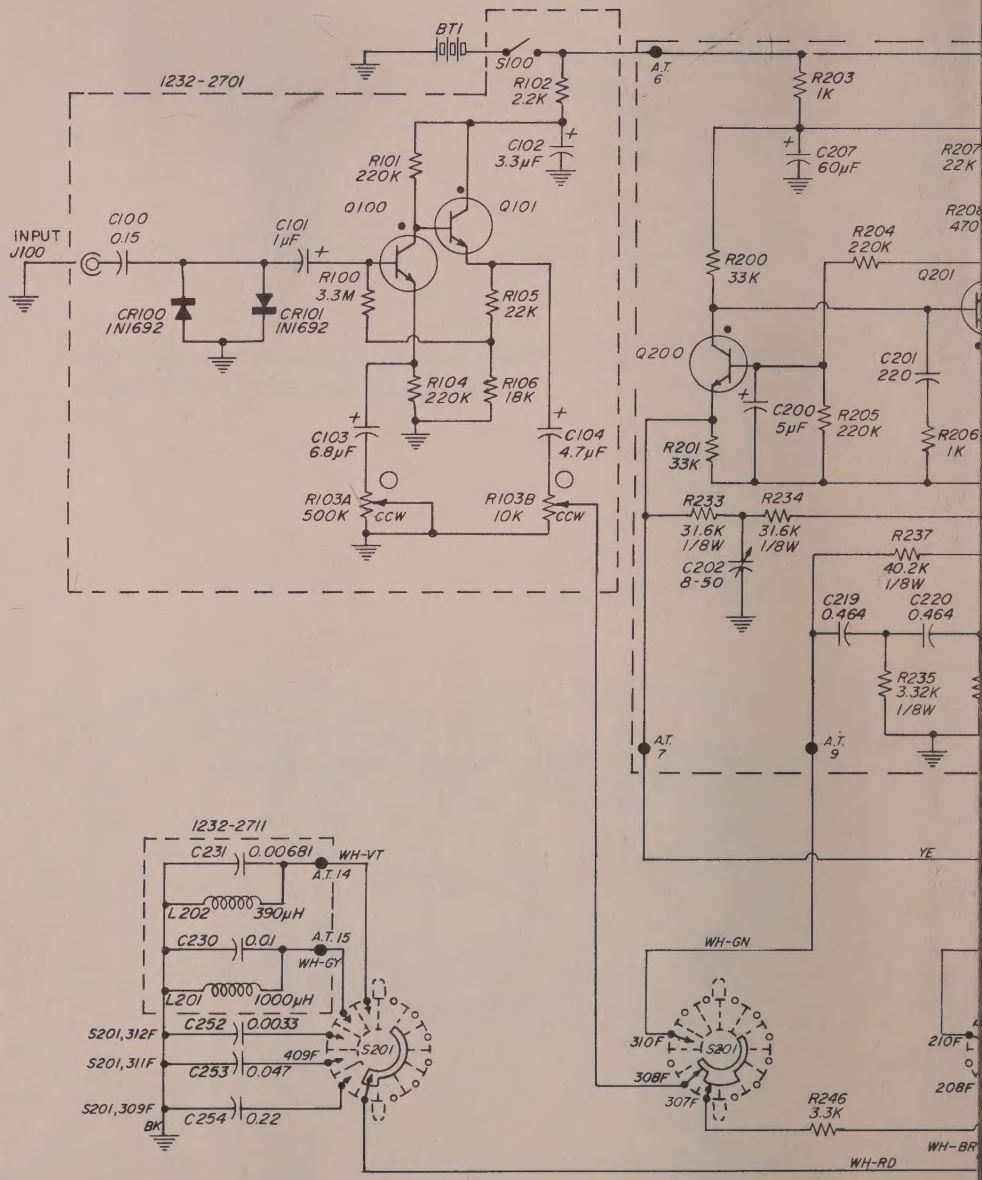
NOTES

A. Resistances are in ohms except as otherwise indicated by k (kilohms) or M (megohms).

B. Type designations for resistors and capacitors are as follows:
   - COC - Capacitor, ceramic
   - COE - Capacitor, electrolytic
   - COM - Capacitor, mica
   - COP - Capacitor, plastic
   - REC - Resistor, composition
   - REF - Resistor, film

C. Capacitances are in pf except as otherwise indicated

D. Q100 and Q101 are specially selected transistors; refer to paragraph 4.4.


BT1
S100
1232-2701
R102 2.2K
C102 3.3μF
R101 220K
Q100
Q101
INPUT J100
C100 0.15
C101 1μF
R100 3.3M
CR100 1N1692
CR101 1N1692
R105 22K
R104 220K
R106 18K
C103 6.8μF
C104 4.7μF
R103A 500K
CCW
R103B 10K
CCW
A.T. 6
R203 1K
C207 60μF
R207 22K
R204 220K
R200 33K
Q200
Q201
C201 220
C200 5μF
R205 220K
R206 1K
R201 33K
R233 31.6K 1/8W
R234 31.6K 1/8W
C202 8-50
R237 40.2K 1/8W
C219 0.464
C220 0.464
R235 3.32K 1/8W
A.T. 7
A.T. 9
YE
1232-2711
C231 0.00681
WH-VT
A.T. 14
L202 390μH
C230 0.01
A.T. 15
WH-GY
L201 1000μH
C252 0.0033
S201,312F
S201,311F
C253 0.047
409F
S201
S201,309F
BK
C254 0.22
WH-GN
310F
308F
307F
S201
210F
208F
R246 3.3K
WH-BR
WH-RD
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